

fifth millennium, was next treated. A number of the extremely rare Kappadolian tablets, of which more than sixty have been obtained for the University of Pennsylvania through Dr. Hilprecht's efforts during the last four years, a historical document of the time of King Nabonidus and a marble vase of King Artaxerxes with four inscriptions in Persian, Median, Babylonian and Egyptian languages were likewise exhibited and partly interpreted.

Dr. Charles L. Leonard then read a paper on a "New Physical Property of the X-Ray."

Dr. Frazer reported that the preparation of the plates for the reproduction of the signature book would require an additional appropriation of \$80.

On motion of Mr. McKean, the appropriation was made.

Mr. Goodwin then moved that the Secretaries be instructed to prepare from the plates now made 250 copies, to be sold only to members at cost, not more than one copy to be purchased by any one member until further orders from the Society. Carried.

Dr. Morris moved that the Society present to the Wistar Institute a bust of Franklin and one of Dr. Wistar, these being in duplicate. Carried.

The rough minutes were then read, and the Society adjourned.

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*New Physical Phenomena of the X-Ray.*

*By Charles Lester Leonard, A.M., M.D.*

*(Read before the American Philosophical Society, November 20, 1896.)*

The physical phenomena connected with the x-ray are at present limited to those announced by their discoverer, Prof. Wilhelm Konrad Röntgen. They are their power to penetrate substances formerly considered opaque, their chemical action exhibited upon the photographic film and fluorescent screen, and their power of discharging electrified bodies whether positively or negatively charged.

The simple experiments which I conducted at the Pepper Laboratory

of Clinical Medicine seem to prove that another physical characteristic of the x-ray is now known.

In heating a double-cathode x-ray tube of the focus type, while it was energized by an alternating current, the following phenomenon was noted.

When the alcohol lamp was held at a point midway between the cathodes and at a distance varying from one-half to three inches from the reflectors, the x-ray, as shown in the fluoroscope, and the fluorescence within the tube were seemingly extinguished.

This was true in tube A, and in no other tube of the double cathode focus type.

What was the form of interference which the lamp exerted, and why did it apply to one tube and not to all of that type?

These queries led to the following experiments in which I was assisted by Mr. Alfred Watch.

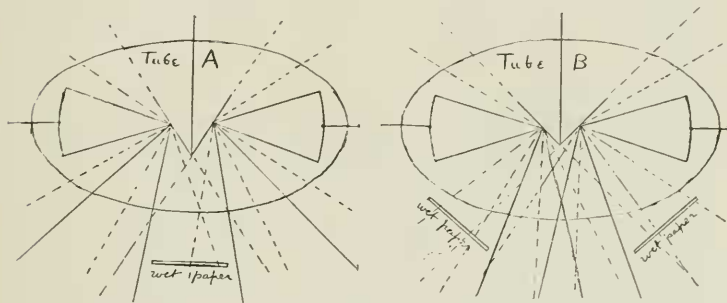


Diagram of X-Ray Tubes. Cathode Rays ————, X-Rays . . . . .

Basing our experiments upon the theory, that it was the aqueous vapor, produced by the combustion of the alcohol, which caused this phenomenon, we substituted for the alcohol lamp a small piece of filter paper saturated with water, and obtained the same result. There was no effect upon the other tubes, the discharge of x-rays and the fluorescence remaining unaltered. On approaching the wet paper to the cathode a streaming of electricity was observed from the paper or lamp vapor towards the cathode through the wall of the tube and was observed to diminish in quantity as the paper was carried towards the point midway between the cathodes and opposite the reflector, and when it reached this point the x-ray and fluorescence ceased. At all points outside the tube a grounded wire drew a spark from the burner of the lamp, or from the moistened paper. This experiment seems to show that there can be established outside of the x-ray tube a connection between one cathode and the other capable of modifying the effect of the electrical discharge within the tube.

This was proved by using a piece of wet paper so shaped that it ex-

tended from cathode to cathode outside the tube. The x-rays and fluorescence were seemingly destroyed in this manner in all forms of double cathode tubes used with the alternating current.

The form of interference which was first observed was therefore the establishment of a path for the conduction of the electricity from cathode to cathode outside the x-ray tube, or in other words the completion of a short circuit between the cathodes in the induced electric field outside the tube.

But why was it possible to complete this short circuit, in one tube, by introducing the aqueous vapor at a single point opposite the reflector and midway between the cathodes, and impossible to do it in any other tube of the same type? Is there any reasonable theory which will logically explain this difference?

A critical examination of two tubes of this type shows that in tube A the cathodes are in such relation to the planes of the reflector that light, obeying the law of reflection, and emanating from the cathodes, would be reflected at such an angle as to leave a wedge-shaped area beneath the reflectors and between the two bundles of rays, free from their interference.

An examination of tube B shows that no such area would be formed, and that the two bundles of rays would be united in the median line.

The fluoroscope shows that this median area is the area of most intense fluorescence, as x-rays enter it from both reflectors.

Suppose the rays obeying the law of reflection within the tube are the cathode rays, which become the Lenard rays outside the tube.

In tube A they would be reflected from the median line and leave a field of x-rays free from their interference. We have then here a purer field of x-rays, which would easily account for the greater rapidity and sharpness of definition which this tube has exhibited, as illustrated by the unintensified half-minute exposure negatives of the hand and other objects, and the six-minute exposure of the normal trunk of a five-year-old boy.

Would this supposition account for the absence of a conductive area midway between the two cathodes, which, when supplied by the aqueous vapor, results in the extinguishing of the x-ray and fluorescence? It would, if we consider the Lenard rays to be capable of conducting electricity while the x-rays are not. Under these conditions the aqueous vapor between the bundles of Lenard rays, in the case of tube A, would form the connecting link in the short circuit between the cathodes. But how about tube B—if this theory is correct, how can we explain the difference in the phenomenon observed in it?

In this tube we saw, that the bundles of reflected Lenard rays occupied the median field beneath the reflectors and were continuous, while the areas of non-conduction lay between the cathodes and the bundles of Lenard rays.

By placing two small pieces of moistened paper in these two non-

conductive areas, and thus supplying the conductor, the theory is proved to be correct, for the x-rays and fluorescence are seemingly extinguished and we have established the short circuit in both tubes through the medium of the Lenard rays and the aqueous vapor.

The following conclusions may be drawn from these experiments :

1. From the fact that a short circuit may be established between the cathodes in an induced electric field outside the tube, by placing an electrical conductor in certain positions outside the tube, not occupied by the Lenard rays, but occupied by the x-rays, we may conclude that the Lenard rays are conductors of electricity, while the x-rays are not. This would also account for the difference in the action of magnetic fields upon the cathode or Lenard rays and the x-rays, and, conversely, that action would confirm the deduction regarding the conductivity and non-conductivity of the two rays.

This deduction is also compatible with the phenomena observed in the discharge of electrified bodies by the x-ray, the ultra-violet rays, and other forms of light rays.

2. From the condition found to be present in tube A, that is, the presence of an area which is a non-conductor of electricity and is free from Lenard rays, and yet is the area of most intense x-rays, we may conclude that the x-ray emanates from the surface of the reflector in this type of tube, and is not due to the bombardment of the wall of the tube by the cathode rays, as no cathode rays strike the wall of the tube in the area from which we find the greatest fluorescence.

Further, from the fact that the x-ray is a non-conductor and is not influenced by a magnetic field, while the Lenard rays are conductors and are influenced by magnetic fields, it would seem probable that these two forms of radiant energy differ essentially in their character, the x-ray presenting most of the phenomena characteristic of light, while the Lenard rays present the phenomena of radiant matter.

3. From the difference in the rapidity of the action of the two tubes on the sensitive film we may conclude, that the presence of Lenard rays in an x-ray field interferes with the photographic action of the x-ray: consequently a tube of the greatest efficiency would be one so constructed, that the Lenard rays would be reflected entirely outside of the most intense x-ray field.

It would seem probable that the efficiency of the focus type of x-ray tube is in a measure due to such a reflection of the Lenard rays, as many of those working with the single cathode focus tube have found, that the point of greatest intensity of the x-ray is not at the point where rays of ordinary light would be reflected if they emanated from the cathode, that is, the point to which the Lenard rays are reflected, but is at a point perpendicular to the focal point of the cathode rays upon the platinum reflector.